Advertising Budgeting and Geographic Allocation:
A Decision Calculus Approach

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Many firms view their market as being made up of geographic subunits. The areas may be different in terms of local product preferences, media efficiency, competition, distribution, price, and margins. If these heterogeneities are to be considered in finding the best advertising budget, the problem becomes one of simultaneously setting a budget level and allocating it to geographic areas. The simultaneity results because the overall profitability of a given budget level is not known until it is allocated in the most profitable manner. But the final allocation is not known until the best budget level is specified as a constraint for the allocation. The problem is more complex in most cases since advertising dollars can be used to buy national media (umbrella converage) or local media. Therefore, the allocation is to each local area and national coverage.

Almost all existing budgeting models assume completely homogeneous markets, but some aspects of heterogeneity have been considered in advertising allocation models.[1] Given that the total expenditure level is fixed, Nordin considered allocation to areas when sales response between areas differed.[2] However, he did not consider carryover, competition, or media effects. Zentler and Ryde built a more elaborate allocation model that included carryover effects.[3] Friedman

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[1]See David B. Montgomery and Glen L. Urban, Management Science in Marketing (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1969), pp. 94-157, 276-279.

[2]J. A. Nordin, "Spatial Allocation of Selling Expenses," Journal of Marketing, Vol. 3 (January 1943), pp. 210-219.

[3]A. P. Zentler and Dorothy Ryde, "An Optimum Geographic Distribution of Publicity Expenditure in a Private Organization," Management Science (July 1956), pp. 337-352.

constructed a game theoretic allocation model to consider competitive effects.[4] The most comprehensive consideration of heterogeneity is in MEDIAC.[5] MEDIAC is a media selection model, but it could consider differences in response functions, carryover, competition, and media options between areas when each area is considered to be a market segment. MEDIAC, however, is not well equipped to handle the budgeting and allocation problem since it requires the budget to be given and if, for example, 30 market areas are of interest in the allocation, the number of national and local media options would exceed the computational capabilities of MEDIAC. The only model that considers both the total budget level and local allocation is the variable budgeting model of Friedman.[6] But Friedman's model only encompases local media efficiency differences between areas and assumes all the response functions and prices are the same across areas. This paper will develop a model for setting the total advertising budget and allocating it to geographic regions that includes consideration of heterogeneity due to growth rates, advertising responsiveness, media efficiencies and availability, profit margins, distribution, competition, and carryover.

In addition to the weakness due to incompleteness of existing models for the solution of the budgeting and allocation problems, these models suffer from a lack of usage. Marschner studied the existing procedures for advertising

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[4] Lawrence Friedman, "Game Theory Models in the Allocation of Advertising Expenditure," Operations Research, 6 (September-October 1968), pp. 699-709.

[5] John D. C. Little and Leonard M. Lodish, "A Media Planning Calculus," Operations Research, 17 (January-February) pp. 1-35; and Leonard M. Lodish, "Considering Competition in Media Planning," Management Science, 17 (February 1971) pp. 293-306.

[6] Lawrence Friedman, "A Variable Budgeting System for Consumer Advertising," Sloan Management Review, 12 (Winter 1971), pp. 77-86.

allocation of two "large, successful, and knowledgable American Marketers."[7] He found that both were allocating advertising to areas on the basis of past sales in those areas. One firm basically calculated the total budget for the year divided by the total sales last year and then multiplied the dollars per sales unit times the sales in each area last year to define the local expenditure. The other firm had a much more complex protocall that produced basically the same policy of allocating dollars in proportion to the sales volume already achieved in an area. These procedures are not atypical in the author's experience and it is clear that the gap between theory and practice is large.

The purpose of this paper is to describe the development of a model that combines the important theoretical concepts underlying advertising budgeting along with a measurement support program to produce a model that can be adopted and used by managers. Such an "implementable" model has been called a "decision calculus" by Little.[8] After specifying a set of criteria for a decision calculus, a model for advertising budgeting and allocation reflecting these criteria is proposed. The paper closes with a report of an application of the model which includes a discussion of estimation procedures and problems, output, and implementation progress.

Criteria for Implementable Models

It is relatively easy to build a complex optimization model of advertising, but it is difficult to build an adequate model that will be used by managers. Particularly in marketing, there are few (if any) companies using a sophisticated

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[7] Donald C. Marschner, "Theory Versus Practice in Allocating Advertising Money," Journal of Business, 40 (July 1967), pp. 286-362.

[8] John D. C. Little, "Models and Managers: The Concept of a Decision Calculus," Management Science, 16 (April 1970), pp. 466-487.

management science marketing model on a continuing multiple manager and brand basis. One reason for this lack of implementation of models is that models have not been built with this goal in mind. Little has proposed the "decision calculus" concept to aid in model building. He defines a decision calculus as, "a model based set of procedures for processing data and judgments to assist a manager in his decision making."[9] He suggests a model should be: (1) understandable, (2) complete, (3) evolutionary, (4) easy to control, (5) easy to communicate with, (6) robust, and (7) adaptive.[10]

The first criterion - understandable - requires a simple model structure that is perceptibly similar to how the manager thinks. For example, process flow model are usually intuitively acceptable to managers, while a linear programming equation is not. If the model is not a process model, it will be more understandable if it can be represented graphically and with a minimum of mathematics. Understanding applies not only to the manager formulating a plan, but to the levels in the organizational hierarchy which review plans. If the model is not understandable to middle and top management they probably will not accept the new decision procedure.

The second criterion is completeness and it demands that none of the factors or phenomena important to the manager's definition of the problem are omitted. This is in conflict with the first criterion since most decisions are complex, and completeness implies a model that is difficult to understand. Criterion three allows an escape from this conflict. If a simple model can

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[9] Ibid, p470.

[10] This paper adds "evolutionary" to the list of criteria, renames the criterion for a "simple" model as an "understandable" model, and extends Little's discussion of the "control" and "adaptive" criteria.

evolve to a more complete model in a smooth manner, the manager can be taught the basic structure at a simple level and then evolve to a complete model.[11]

Perhaps the most important criterion is control. The manager must feel it is "his" model and that it reflects a refined statement of his implicit model. The model, if it is to be used on a continuing basis, must be viewed as a necessary tool for his work. He must not feel that in using the model he is delegating his decision prerogatives, but rather that the model is helping him to exercise them. The manager should control the model to the extent that he could manipulate the model, if he so desires. That is, he should know the inputs necessary to get specific outputs.

A complete and understandable model encourages the feeling of control, but the use of on-line computers has made it feasible for the manager to directly interact with a model. The use of a good conversational program and graphical display allow a manager to communicate easily with the model from his office via a remote terminal. This element of control and ease of use are important to the internalization process.

The process of acceptance can be reinforced by a robust model. The model should not produce wildly unexpected results. For example, a linear advertising budgeting model is not robust since it will lead to an optimal level of advertising at plus infinity or zero. The model should be structured to give reasonable answers and the output be restricted to reasonable ranges such as the limits of the data used for estimation. In using a robust model, the manager gains confidence and is not distracted by inappropriate asymptotic outcomes.

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[11] See Glen L. Urban and Richard Karash, "Evolutionary Model Building," Journal of Marketing Research, 8 (February 1971), pp. 62-66.

Given a model that meets the above criteria, the next question is how the model parameters will be obtained. A model will be more heavily used if its parameters are data based. Initially, in order to meet the completeness criterion, it will obviously be necessary to rely heavily on subjective inputs, but the use of the model will aid the manager in specifying his data needs and encourage him to use the data after it has been collected. In some cases, historical regression is informative about parameters, but in most marketing models causual inferences are required that can be gained best by experimentation. Model builders should realize at the initiation of the project that experiments will probably have to be conducted and should plan and budget for a subsequent data acquisition phase. The most ideal data basing system is one that utilizes continuing experimentation and permits adaptive control. In this way, the model can be updated to reflect changes in response while the continual updating and refining will build managerial confidence in the new decision structure.

During the parameterization and updating of the model, it is important to allow managerial judgment to enter the process. The model should be structured so that the manager can relate his experience to the parameters. It may seem unnecessary to require this if experiments are conducted, but in marketing, at least, experiments tend to be confounded by uncontrollable factors (e.g. competitors and middle-men) and the marketing effects are sometimes small relative to the variance in sales. This means the statistical results usually require interpretation before use in a normative model. This interpretation is facilitated if the manager understands the model.

Utilization of data based parameter estimates is also valuable since it protects against inappropriate use of the model. The ability to control and understand a model fully allows the manager to manipulate the model. It may, therefore, be used abusively. With data-based estimates, departures from the estimates can be examined and review procedures can require that differences be explained. If little empirical data exists, the model should be in a form so that other managers can relate their judgments to the model and thereby assess the quality of subjective inputs.

The model-based criteria outlined above are necessary but not sufficient for implementation. In addition to building a model with these properties, it is essential to make management aware of the potentials and pitfalls of models. This education must occur at all levels since top management support is required. Top level support is important to the potential model users since model work must be recognized as legitimate so that time devoted to the model will be compatible with the user's career goals. The time required by models is large, so organizational pressures must be created to cause significant slices of time to be allocated to planning. When forced to choose between "putting out a fire" and planning, most managers are likely to opt for the former activity. Models may be a mechanism to put managers to work at their real task, but this will reflect a change in most operations and may require overt modifications.

Given an understandable, complete, evolutionary, controllable, robust, and data based model with the proper organizational environment, continuing usage can occur. If all these elements are needed, it is not surprising to find little internalization of models into management decision procedures

The next section describes a model of advertising budgeting and allocation that was built in an attempt to meet these criteria.

Model Structure

The purpose of the model is to aid in the process of determining the size of a total advertising budget and allocating it to geographic areas. The most basic component of the model can be represented by a graph of sales versus advertising. See Figure One. Such a graph may be thought to exist for each area and relates a measure of advertising in a local area to sales changes from a reference sales forecast. This graphical structure is used since it is understandable and intuitively appealing for managers in defining the marginal response to advertising. Note that sales changes are measured relative to a reference sales level. This structure is used since most firms have a forecasting mechanism that is institutionalized. The use of forecasted sales as a reference makes the model compatible to an existing procedure that is familiar to the manager. The model, therefore, is perceived to be an improvement in the existing process and not a replacement of an accepted current procedure.

For purposes of estimating response, advertising dollar expenditure is not the best measure because media differences exist between national and local areas. In order to define an operational measure of the advertising pressure that exists in an area, consider the basic flow of advertising expenditure. See Figure Two. Part of the total budget goes to national media with some share of this falling on a local area and part allocated directly to a local area. The advertising that is seen in a local area is from a combination of national and local media. The concept of weighted advertising is used to define a common

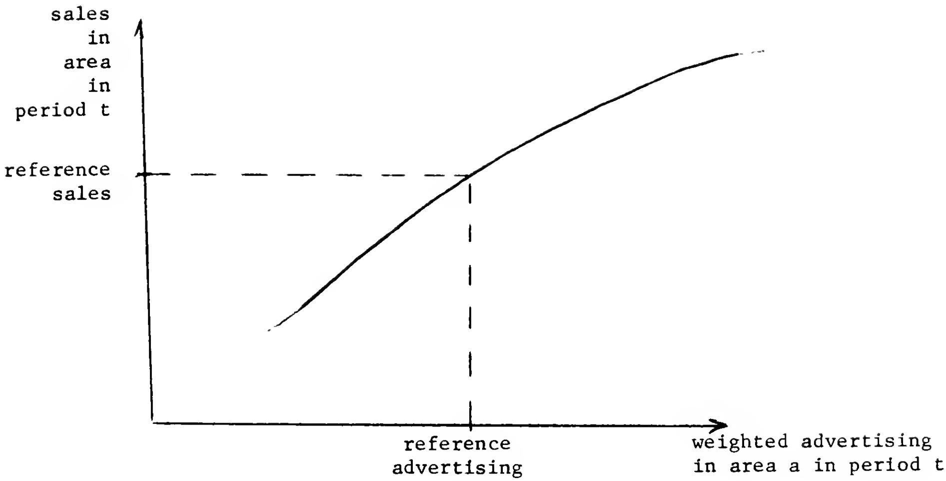

FIGURE ONE

ADVERTISING RESPONSE

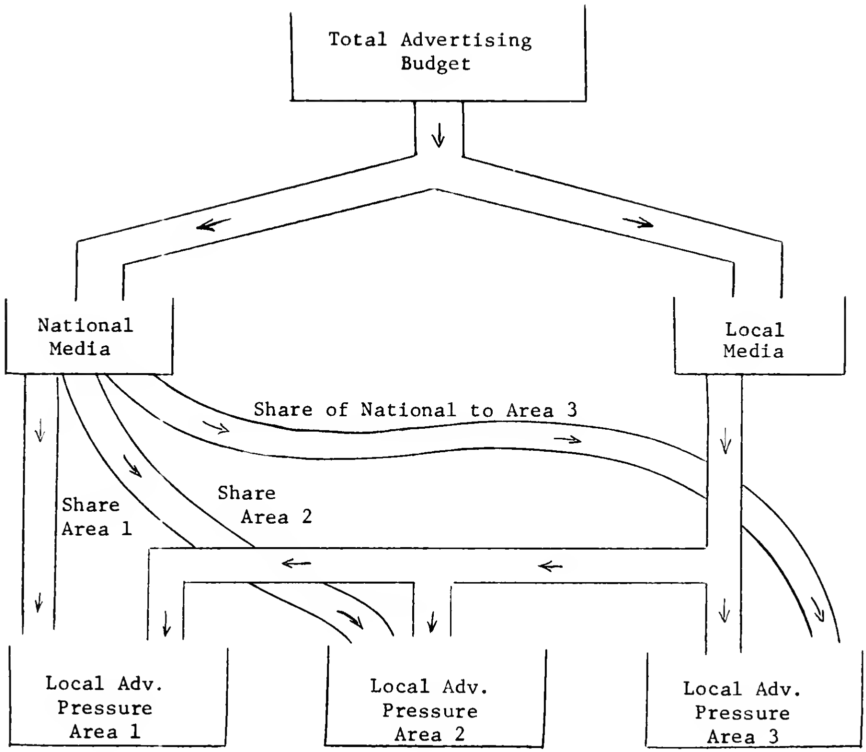

FIGURE 2: Advertising Flow

measure for advertising pressure in an area. National media dollars are used as the standard measure and local media dollars are weighted to reflect differences between national and local media exposure, impact, and efficiency. The weighting is based on a ratio of the rated exposure value per dollar in the local area to the rated exposure value per dollar in the national media. The rated exposure value is the sum of the exposures in each media multiplied by a media rating which reflects its impact given exposure. The rated exposure value per dollar is the rated value divided by the advertising expenditure required to obtain it. Formally, the rated exposure per dollar nationally is:

$$(1)\quad REVND_t = \sum_{p=1}^{NP}\sum_{m=1}^{M} EXPOSN_{p,m} \cdot RATING_m \Big/ \sum_{p=1}^{NP}\sum_{m=1}^{M} COSTN_{p,m}$$

$REVND_t$ = Rated Exposure Value Nationally per Dollar at time t[12]

$EXPOSN_{p,m}$ = number of EXPOSures or audience impressions obtained in media m at period p for National spending

$COSTN_{p,m}$ = COST Nationally in media m in period p (i.e. cost to obtain $EXPOSN_{p,m}$)

$RATING_m$ = media RATING or exposure value index for media m

NP = number of past periods of data to be used to estimate REVND (e.g. last year or for separate quarters)

M = number of media considered

[12] Such variable names are used since, when displaying an equation to a manager, a nemonic English word is easier to understand than a Greek symbol.

Similarly, the rated exposure value per dollar locally is:

$$(2)\quad REVLD_{a,t} = \sum_{p=1}^{NP} \sum_{m=1}^{M} EXPOSL_{a,p,m} \cdot RATING_{m} \Big/ \sum_{p=1}^{NP} \sum_{m=1}^{M} COSTL_{a,p,m}$$

$REVLD_{a,t}$ = Rated Exposure Value per Dollar Locally in area a at time t

$EXPOSL_{a,p,m}$ = number of EXPOSures obtained in media m in period p in Local area a

$COSTL_{a,p,m}$ = COST in Local area a in period p for purchase in media m

The ratio of REVLD to REVND is used to weight local expenditures so that all areas will be scaled relative to the national media standard. In addition, when specifying weighted advertising, two indices are allowed to change the effectiveness of national spending and the relative weighting of local expenditure.

The weighted advertising in a local area is:

$$(3)\quad WTADVL_{a,t} = ADVNAT_t \cdot SHRLOC_{a,t} \cdot EFFNAT_t + ADVLOC_{a,t} \cdot \frac{REVLD_{a,t}}{REVND_t} \cdot RIMPCT_{a,t}$$

$WTADVL_{a,t}$ = WeighTed ADVertising in Local area a in time period t

$ADVNAT_t$ = ADVertising dollar expenditure on NATional media in period t

$SHRLOC_{a,t}$ = SHaRe of national media expenditure that falls in LOCal area a in period t

$EFFNAT_t$ = EFFectiveness of NATional media at time t. (Set to 1.0 initially.)

$ADVLOC_{a,t}$ = ADVertising dollar expenditrue in LOCal area a in period t

$REVLD_{a,t}$ = Rated Exposure Value Locally per Dollar in local area a in period t

$REVND_t$ = Rated Exposure Value Nationally per Dollar in period t

$RIMPCT_{a,t}$ = Relative IMPaCT of local media to national media in area a in period t. (Set initially to 1.0.)

In order to allow for completeness, the two indices are included in the equation so that the manager can make changes to reflect future conditions that might be different from the past. EFFNAT is an index which can be used to change the

effectiveness of national media expenditure relative to past national media and RIMPCT is an index which can be used to change the impact of local expenditure relative to national. The indices might also be used to reflect seasonal media characteristics.

Weighted advertising is the independent variable in the model and is linked to the sales as shown in Figure One. In this structure, the sales that result from an advertising change are the original forecast times a response function index derived from Figure One. The function will have a value of one at the budget level corresponding to the reference sales forecast and other values for alternate weighted advertising levels. A general function is used to relate weighted advertising and sales. Initially, sales are specified by:

$$(4)\quad TSALEL_{a,t} = RSALEL_{a,t} \cdot ADVRSP_{a}\,(WTADVL_{a,t} \,/\, WTADVLR_{a,t})$$

$TSALEL_{a,t}$ = Temporary forecast of SALEs in Local area a in period t

$RSALEL_{a,t}$ = Reference SALEs in Local area a in period t in reference advertising plan is carried out

$ADVRSP_{a}$ = ADVertising ReSPonse function describing proportionate changes in sales from reference ($RSALEL_{a,t}$) for a change in weighted advertising ($WTADVL_{a,t}$) relative to the weighted advertising implied by the reference plan ($WTADVLR_{a,t}$) in local area a

The function (ADVRSP) will generally experience diminishing returns, but must be determined for each area. The model does not restrict itself to a prespecified methematical curve. Rather the curve is drawn based on experimental data or subjective estimates. This approach is preferred by managers since they can relate to a graph better than an equation. In the future this graphical input could be by light pen computer graphics.

In addition to the one period response to advertising, the effects of advertising in one period on future period sales must be portrayed. The phenomenon of carryover effects due to brand loyalty, word of mouth, and remembering is included in the model by specifying how much of the change in sales from reference in one period is retained in the next period. The model considers the carryover in terms of changes since the reference sales forecast implies the carryover for the reference budget. The change in sales in area a in period t-1 (DSALEL) is:

$$(5)\quad DSALEL_{a,t-1} = SALEL_{a,t-1} - RSALEL_{a,t-1}$$

$SALEL_{a,t-1}$ = SALEs in Local area a in period t-1 (See Equation 7)

$RSALEL_{a,t-1}$ = Reference SALEs in Local area a in period t-1 if reference advertising plan is carried out

The amount of this sales change that is retained from the last period is:

$$(6)\quad RETSLL_{a,t-1} = DSALEL_{a,t-1} \cdot RETRT_{a}$$

$RETSLL_{a,t-1}$ = RETained SaLes in Local area a from period t-1

$RETRT_{a}$ = RETention RaTe for area a

The retention rate reflects carryover effects in the local area. The retained sales will effect the sales of the next period. The model changes this period's sales by the proportion of retained sales to last period's sales to obtain the final sales level (SALEL):

$$(7)\quad SALEL_{a,t} = TSALEL_{a,t} \cdot (1 + (RETSLL_{a,t-1} / RSALEL_{a,t-1}))$$

This proportionate change assures that the original seasonal pattern of reference sales is maintained since it presumes the retained sales follow the seasonal pattern.

The sales are linked to profit by the usual accounting definitions. The total contribution profit is:

$$(8)\quad TPROF_t = \sum_a (SALEL_{a,t} \cdot PMARGN_{a,t}) - ADVLOC_{a,t} - ADVNAT_t$$

$PMARGN_{a,t}$ = Profit contribution MARGiN in area a and time t (in units of dollars per sales unit)

The value of the contribution margin (PMARGN) will reflect the pricing situation in an area and the variable cost of the product in an area.

The total profit over a planning period defines the criteria of evaluation for the model.

$$(9)\quad TTPROF = \sum_{t=1}^{PP} TPROF_t$$

where PP = number of periods in the planning period.

This completes the initial model structure. The model is intended to encompass the necessary phenomena, but be understandable to managers. It represents a basis for evolution. Specifically the model could be modified to include other variables. For example, the effects of distribution levels has been incorporated. Distribution is included in the model by adjusting sales to full distribution sales and then multiplying by the percent of the market covered by an alternate distribution plan. The adjusted sales level (ASALEL) is:

(10) $ASALEL_{a,t} = (TSALEL_{a,t} \;/\; AVAIL_a\,(RDISTL_{a,t})) \cdot AVAIL_a\,(DISTL_{a,t})$

$AVAIL_a$ = AVAILability function defined as percent of market covered at a given distribution level ($DISTL_{a,t}$) in area a in period t

$RDISTL_{a,t}$ = Reference DISTribution level in Local area a in period t

$DISTL_{a,t}$ = DISTribution level in Local area a in period t

The distribution level is defined as the percent of outlets that carry the product and is functionally related to the percentage coverage by AVAIL. ASALEL is then substituted in place of TSALEL in Equation 7. Similar extensions could be made to include price and point of purchase effects. Another area for evolution is in the representation of competitive effects. Presently, competitive effects are included indirectly in each area's retention rate (see Equation 6) and in the response curves (see Equation 4). This assumes competitors will behave as they have in the past despite our advertising changes. Future evolutionary development of the model could separate the competitive effect. This could be accomplished by making advertising response (ADVRSP, Equation 4) a function of our expenditure relative to competition or, more elegantly, by creating a ratio of our advertising to the sum of all firms' advertising, each raised to a sensitivity exponent.[13] With an explicit competitive formulation, payoffs could be found for various competitive strategies, and Bayesian decision or game theory procedures could be utilized. It is hoped that the existing simple model is adequate in terms of its completeness, but the evolutionary capability can be utilized if a manager needs or desires a more comprehensive model.

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[13] See Glen L. Urban, "A Mathematical Modeling Approach to Product Line Decisions," Journal of Marketing Research 5 (February 1969): 40-7.

Heuristic Solution Procedure

The model described in the previous section has a control variable for the advertising level in each area and one for a national expenditure. If changes are made in the advertising levels, a non-linear response occurs and is spread over a number of periods (see Equations 3-7). The problem is to find the best total budget and allocation. The size of this problem is unusually large since most analyses will include 20 to 30 areas and 4 to 8 quarters. The nature of the weighted advertising function also complicates the solution procedure since each time the national media expenditure is changed, the weighted advertising in each area changes (see Equation 3). This will then change all the marginal responses for each area's local expenditure. Also recall that the advertising response is general and could admit "S" curves. Dynamic programming could be used to carry out the local allocation, but when alternate total budgets and national media expenditures are entertained the state space and number of alternatives becomes very large and storage requirements exceed the capabilities of today's computers. In addition to storage problems, it should be recalled that the model is to be run on-line by managers. The time necessary to solve a problem of this size by dynamic programming would require the managers to wait intollerably long periods of time before receiving an answer. The long run times would also make usage of the model very expensive.

In view of these problems, a heuristic solution procedure is used. The heuristic is structured to involve the manager. This is done by using an on-line search procedure and defining the three levels of operation for the heuristic. The levels are "allocate", "split" and "search". At each

level the manager interacts with the procedure so that his knowledge of the manager and the power of the search rule can be combined to efficiently find a good and perhaps best strategy.

"Allocate" takes the total budget and national advertising level as given and allocates the total local expenditure to each area in an attempt to maximize the total profit over the planning period. This is accomplished by a rather straight forward marginal profit analysis. After calculating profit marginals in areas, money is switched from the area with the lowest marginal to the area with the highest marginal. The heuristic is careful in this process to retain the seasonal pattern of each area by moving a total amount from one area and placing it in the other area in proportion to the new area's expenditure pattern.

The allocation heuristic is bounded by two limits. First, it will not allow the weighted advertising to exceed twice the budgeted level. Second, it will not remove all the advertising from an area if it is on the lower portion of an "S" curve. If advertising is removed while on the concave portion of an "S" curve, the marginal will reduce further and more will be removed. This second limit reflects the assumption that a company will not want to completely abandon an area since long run considerations would deem this as improper (e.g. damage to trade relations). Both these limits are included to help the model meet the criteria of robustness by restricting the output to a reasonable range.

The marginal analysis and shifting of funds occurs until the total profit increases by less than some tolerance. The allocation heuristic is controlled by the amount of advertising moved in generating the marginals and the tolerance. A good procedure is to start with a large advertising

increment (e.g. 25%) and tolerance (e.g. 25%) and then after finding a solution repeat the analysis with a lower increment and tolerance.

"Split" takes the total budget as given and determines how much is apportioned to national media and how much to local media (see Figure Two). Split begins moving expenditures from local to national. If it finds this successful, it continues until improvement is less than a specified tolerance. If split finds the initial movement unprofitable, it moves expenditure from national to local and continues in this direction if profit improvement is greater than the tolerance. At each new total local expenditure level, "allocate" is automatically repeated so the best split also reflects the best allocation. Split is controlled by the amount moved from national to local or local to national and the tolerance that must be exceeded to continue evaluating new alternatives. Split increments advertising from the best pattern of allocation. This minimizes the computation in subsequent utilizations of the allocate heuristic.

"Search" sequentially examines a specified set of total budget alternatives. After each alternative it generates and records the best split and allocation patterns so that the evaluation of the next alternative will begin from the previous best pattern and therefore will require less computation to find the new best plan. The final result of search is the most profitable alternative recommendation of the total budget, split to national expenditure, and allocation to local areas.[14]

The manager is important in the heuristic since he has experience and pattern recognition capabilities that can be useful in efficiently finding solutions.

[14] The computer run times for 30 areas and 8 quarters are about 20 seconds of CPU on a 360/67 per allocation and 40 seconds of CPU for each total budget alternative.

He can specify or change the starting points, examine desired total budgets and iteratively converge on the best solution by changing the search increments and tolerances. The on-line feature of the system also allows parameters to be changed at any stage so sensitivity testing can be conducted on parameters that are in doubt. The managerial involvement in the solution procedures encourages a feeling of control and the perception that the manager is in command.

The heuristic could be extended to include explicitly the sequence of advertising levels. In its current form, the heuristic takes the sequence as given and increments it. Although the sequence could be changed on-line and the heuristic re-run, it would be useful to consider both the level and pattern of expenditure. Again, there is potential for an evolution.

Model Input

The last decision calculus criterion for a model is that it be adaptive. In advertising, measurement has been a difficult problem. It is generally agreed that the response inferences can be best made through experimentation. An adaptive experimental design is desirable since it will help diagnose changes in market response and will refine the response measures over time. An adaptive design is especially attractive for this simple model since the updating could compensate for the lack of detail in modeling the competitive effects.[15] If competition changed its strategy, the quarterly update would yield new information for the revised sales curve. Table 1 indicates the input

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[15] John D. C. Little, "A Model of Adaptive Control of Promotional Spending," Operations Research, 14 (November-December 1966), pp. 1075-1097.

Input Name			Source of Data
I Reference Plans			
Sales			
RSALEL (4)*			Internal forecasting mechanism
Planned advertising			
ADVNAT (3)			
ADVLOC (3)			
II Exposure Data			
REVND	(3)	EXPOSN(1) COSTN(1) RATING(1)	Advertising agency contract records and media data
REVLD	(3)	EPOSL(2) COSTL(2) RATING(2)	
SHRLOC	(3)		
III Response Measures			
Retention rates			
RETRT (6)			Statistical analysis of past data and experimentation and subjective estimates
Advertising response			
ADVRSP (4)			
IV Profit			
PMARGN (8)			Accounting records

*Equation numbers

TABLE 1: Model Input

requirements and data sources. The response data are based on experiments and judgment while the other inputs come from internal company or advertising agency records.

Model Application

This budgeting and allocation model has been applied to a frequently purchased consumer product produced by a medium sized firm. The product is part of a large product class, but enjoys a unique position within it. This application section will discuss the prior analysis, design of the experiment, analysis of experimental results, model runs, and state of implementation.

Prior Analysis:

The initial response parameters were based on a regression analysis of 5 years of monthly sales data, records of advertising expenditure and media exposure data. The data on advertising was combined by calculating the weighted advertising (see Equation 1-3) and used as a measure of advertising pressure in each area in the statistical analysis to determine advertising response. **Exploratory plots of** advertising and distribution data showed a strong seasonal pattern with highest sales in the summer, but advertising did not follow the seasonal pattern -- largest advertising generally occured in the fall.

Linear and log linear regressions were run using the model:

$$(10)\quad S_t = b_0 + b_1 WA_t + b_2 S_{t-1} + \varepsilon$$

where S_t = deseasonalized sales per capita in the area in month t

WA_t = weighted advertising per capita in the area in month t

ε = $N(0, I\sigma^2)$

The regression results were significant (F significant at 10% in all regressions) with high R^2 (all greater than 70%). The lagged sales terms were significant at 10% level and coefficients were large (70% of areas greater than .8). However, the coefficients of advertising were generally insignificant and small or negative. This could imply no advertising effect, but since the product was new in this period, the sales were known to have been highly related to advertising. Residual analysis showed little auto correlation, so a more likely explanation of the low advertising effects was inappropriate deseasonalizing. This is especially critical since advertising did not always follow the seasonal pattern. Approaches to seasonality were made based on the use of dummy variables, a prior seasonal model, and 12 month lags, but in all cases the advertising coefficients were small or negative and generally insignificant. However, the regression model was good on a predictive test against 12 months of data saved for forecast evaluation. The error of month by month estimates was 11 percent. Either advertising was confounded with the seasonal effect or sales were not responsive to advertising.

To examine this question further, cross-sectional regressions were run. Since the presumption in building a local allocation model is that area responses are different, one could not pool all areas in a single regression. However, some areas may be basically similar and represent a basis for cross sectional regression. In order to find such groups, the ratio of total sales over four years to total advertising over four years was considered for each area. On the basis of this measure of average responses, three homogeneous groups were formed. Group I had the highest average response, Group II intermediate average response, and Group III low response. Regressions of sales and advertising were run for each of three years in each group. The cross sectional regressions were

significant and indicated positive response to advertising in each group. The examination of subjective response curves generated by company executives also indicated high responsiveness to advertising.

In summary, the prior data analysis was contradictory and not very informative, so the need for experimentation was clearly indicated. The lack of controlled variation in advertising and the seasonality made isolating the advertising effect impossible. Before a decision to experiment was made, model runs were carried out with various curves for advertising response. Even with what management considered "conservative" estimates, the model indicated that higher advertising and a better allocation could lead to substantially higher profits.

Experimental Design:

A four quarter design was used. See Table 2. Twelve areas were selected with four areas coming from each of the response groups defined above. The basic model to be used in analyzing the data was:

$$(12) \quad \Delta S_{t,a} = \beta_0 + \beta_1 \Delta WA_{t,a} + \beta_2 \Delta S_{t-1,a} + \sum_{a=1}^{n} \beta_{2+a} DA_a + \varepsilon$$

$\Delta S_{t,a}$ = change in sales per capita sales from quarter t last year to quarter t this year in area a

$\Delta WA_{t,a}$ = change in weighted advertising per capita from quarter t last year to quarter t this year in area a

DA_a = dummy taking a value of one when area a is present, otherwise zero

n = number of areas

ε = $N(0, I\sigma^2)$

This model will give the slope coefficient of the basic response function (Equation 4) and the retention rate (Equation 6) when last year's sales and

		Quarters			
		1	2	3	4
Group I					
area	1	x	2x	x	x
	2	x	x	2x	2x
	3	x	2x	x	x
	4	x	x	2x	2x
Group II					
area	1	x	1.5x	x	x
	2	x	x	1.5x	1.5x
	3	x	1.5x	x	x
	4	x	x	1.5x	1.5x
Group III					
area	1	x	1.5x	x	x
	2	x	x	1.5x	1.5x
	3	x	.5x	x	x
	4	x	x	.5x	.5x

x = last year's advertising expenditure in area

Table 2: Experimental Design

advertising are used as the reference. Using the change in sales is attractive since it is an effective method of eliminating seasonality. Equation 12 assumes that the advertising would be linear in the range of the experiment. This assumption can be relaxed by estimating β_2 based on a transformation of $\Delta WA_{t,a}$:

$$(13) \quad \Delta WA'_{t,a} = I_{t,a} \left| \Delta WA_{t,a} \right|^{x}$$

where $I_{t,a}$ is +1 if $\Delta WA_{t,a} \geq 0$ and $I_{t,a}$ is -1 if $\Delta WA_{t,a} < 0$. Successive regressions are used to find which x gives the best fit.

The treatment levels were defined relative to last year's expenditure. In the first quarter all areas were at control levels since the model requires one period of lagged sales data. In each of the second to fourth quarters six of the areas received a treatment level which was a multiple of last year's advertising in the areas, while the other six areas were at control levels. See table 2. The treatment multiples were consistent with "conservative" prior model runs. In this analysis treatment multiples were used rather than a constant treatment level of some fixed dollar amount per capita, because a single level would cause little variation in some areas and tremendous variation in others relative to the past per capita advertising levels. In each area, distributors collected data to enable recognition of unexpected environmental changes such as strikes or competitive activity. Ninety percent of the distributors completed the monthly activity questionnaires.

<u>Experimental Results</u>:

After three of the four quarters of the experiment were completed, regressions were conducted to estimate the parameters of Equation 12. One change had to be made to Equation 12. A dummy variable was added to the third quarter to reflect a strike that occurred nationally for a competitive brand.

Based on the analysis of the first three quarters of data,

R^2 was .946, the F was significant at the one percent level, the lagged sales coefficient was equal to .40 and significant at the 15% level, the advertising coefficient was equal to .093 and significant at the 10% level. See Table 2. An inspection of the residuals indicated the errors were approximately normally distributed and showed little auto-correlation or other systematic behavior. Recall that in order to find the heterogeneity of response, experimental areas were grouped into three classes (4 areas per class) based on the average sales response to advertising over the previous four years. When regressions were run for each group, the third quarter dummy was not included since then only one degree of freedom would exist, so results must be interpreted cautiously. In groups I and II, the F statistics were not significant. Since the null hypothesis that all the coefficients are zero could not be rejected, one can not make any statements about the significance of the coefficients in these groups. The Group III regression was significant and while the advertising coefficient is in line with prior beliefs, the large carryover effect was unexpected.

It was hoped that the fourth quarter would add the needed degrees of freedom and improve the estimates within groups. However, a problem occurred in the fourth quarter in four areas where distributors rolled back prices to match the major competitive brand and ran special deals (despite the firm's stated wish to hold all other variables constant). This necessitated adding another dummy variable to Equation 12 for these four areas. For regressions over all areas and the four quarters R^2 was .92 and the F was significant at the 1% level, the lagged advertising coefficient was -.05 and not significant, and the advertising coefficient was .056 and significant at the 10% level. The

	At End of 3rd Quarter	At End of 4th Quarter
Over all Areas		
Advertising Coefficient	.093 (t = 1.46)**	.056 (t = 1.37)**
Carryover	.40 (t = 1.17)*	-.05 (t = -.23)
R^2	.94	.92
R^2 Corrected	.85	.85
df on error	9	20
N	24	36
F	(14, 9) 10.73***	(15, 20) 15.44***
Group I		
Advertising	.21 (t = 2.51)	.055 (t = 2.015)**
Carryover	1.32 (t = 2.31)	.04 (t = .25)
R^2	.83	.977
R^2 Corrected	.32	.932
df	2	4
F	(5, 2) 1.96	(7, 4) 24.78***
Group II		
Advertising	.11 (t = .62)	.121 (t = 1.07)*
Carryover	-.10 (t = -.14)	-.286 (t = -.60)
R^2	.88	.89
R^2 Corrected	.526	.68
df	2	4
F	(5, 2) 2.97	(7, 4) 4.74**
Group III		
Advertising	.092 (t = 1.52)*	.009 (t = .24)
Carryover	1.33 (t = 2.63)**	.148 (t = .52)
R^2	.98	.97
R^2 Corrected	.94	.93
df	2	4
F	(5, 2) 27.61***	(7, 4) 27.98***

Notes: Significance tests on basis of one tail test *15%, **10%, ***5% levels. Degrees of freedom also reflect dummy variables not reported in this table.

TABLE 2: Experimental Results

changes from the three quarter regressions to the four quarter regressions were unexpected. The lagged term became negative (a counter intuitive result) and insignificant, while the advertising response coefficient dropped 50 percent.

The reasons for the effects of fourth quarter sales in changing the estimates are not completely clear. Residual analysis and an examination of the correlation matrix indicated no violations of statistical assumptions. The price changes may be one factor in the differences. Although the fourth quarter dummy is a good way to account for the price roll back, it is crude. This is important since the variance explained by advertising is small (although important) and the fourth quarter dummies may include some of the advertising effect. Inspection of the distributors' reports indicated no especially unusual activity, but many numerous small and diverse local market actions that would increase the noise level were reported. When regressions were run for each response group, the lagged terms were not significant and the advertising coefficients were for Group I .05, Group II .12 and Group III .009. The Group I coefficient was significant at the 10% level, the Group II at the 15% level, and Group III not significant. Since three of the four price roll back areas were in Group I, it was suspected that the .05 advertising coefficient in part reflected the brute force way the dummies extracted the price roll back effect. When Group I and II areas were combined, the advertising coefficient was .073 and significant at the 10% level. The use of the non-linear advertising formulation (see Equation 13) for estimates did not improve the estimates or change the conclusions.

As is not unusual in marketing, the experimental results were not as clean as desired. The unexpected strike and price roll back along with a high sales variance made separating the advertising effect difficult. There was a need for managerial interpretation. Three sets of estimates were formulated.

In each, experimental results were combined with reference conditions, subjective estimates of the saturation sales level of each area, and the minimum sales for zero advertising to specify the response curve. A smooth curve was drawn through the points asymptotically to the two limits. The first set of estimates was based on the first three quarters of the experiment, the second was based on all four quarters of the experiment, and the third based on subjective estimates of the combination of the three and four quarter results (generally these were midway between the two sets of estimates). The third set was deemed by the managers to be their "best" estimates.

The experimental experience re-emphasizes the need to have a decision calculus model so that managers can relate their subjective estimates to the model structure and the statistical results. The results also indicate the need for larger sample sizes, continuing experimentation, and adaptive updating so that over time parameters can be refined and modified for changes in the environment. Eventually experimental time series can be generated for each area so the heterogeniety between areas can be captured in more detail.

Computer Runs:

Output was obtained for each of the different sets of response estimates. Based on the first three quarters of experimental data with the advertising coefficients assumed to be similar in each response group, the model indicated a better allocation could increase profit by 1.8% in the next year.[16] The reference split was found to be best. An increase in the total budget of 75% would increase profit

[16] Although four quarters made up the planning period, the model was run for more to encompass end effects.

13%. The changes in area budgets ranged from -75% to +100%, with an average change of 8%.

Based on the managers' "best" estimates (generally the three quarter experimental results with slope reduced 25%) the runs indicated a 62% increase in the budget would produce 6.8% additional profit. The runs based on conservative four quarter experimental data (no carryover and response coefficients 50% of three quarter results) indicated that 3.5% increase in budget would increase profit 3.4%. Sensitivity analysis on the retention rates, media characteristics, and response curve shapes indicated robustness in the recommendation for a higher budget and its implication for higher profit. Management's conclusions on the basis of the on-line model runs were that an increase in the total budget and reallocation were indicated. The model was used to indicate the direction rather than to specify a final solution. In this type of adaptive system, a ±10 change was reasonable to managers.

Implementation Progress:

This application spans a period of three years. It began by a three day educational effort of the top level management (V.P. Marketing, V.P. Finance and Manager of Systems) followed by one week seminars for the director of marketing research and a marketing manager. After one year of model building, the model responsibility was assigned to the marketing manager. The data responsibilities rested with marketing research with the help of the systems department. Consulting support was supplied, but the marketing manager became a self sufficient user of the model. He operated the model on-line from his office.

The model has been understood by managers through "hands on" experience and exposure and re-exposure to the model structure. The model is viewed as sufficient but not as complete as will ultimately be desired. Specifically, evolution to include other variables, such as competition, is visualized. The marketing manager controls the model through the on-line capability, but improvements are being made in the conversational facility of the program so that the top managers can easily interact with and relate to the model. The robustness of the model recommendations has been appreciated and this helped managers to realize the importance of the direction of the recommendations rather than the specific levels.

The top management decision made on the basis of the experimental results and model runs was to proceed with the evolutionary application of the model. One third of the markets were changed to reflect the model recommendations and to provide new experimental data. Based on the new experimental evidence, the parameters will be updated by Bayesian methods. In light of the experimental problems, there was not enough confidence in the response coefficients to justify full implementation of the model and changing advertising levels in all areas. The potential for full implementation of the model appears to be good, but will probably require one or two more years before it evolves into the status of being fully institutionalized.

Final Comment

This paper has described the development and application of an advertising budgeting and geographic allocation model built on the decision calculus criteria of being understandable, complete, evolutionary, easy to control and communicate with, robust, and adaptive. The model with

experimental data basing has produced some encouraging results. But this experience indicates: (1) the problems of utilizing historical and experimental data, (2) the need for continuing experimentation and adaptive capabilities, (3) the need for a model that will easily accept managerial judgment and interpretation of statistical estimates, (4) the need to integrate model design, parameter estimation, and implementation and (5) the institutionalization of a model as a decision procedure is a long and difficult task.

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